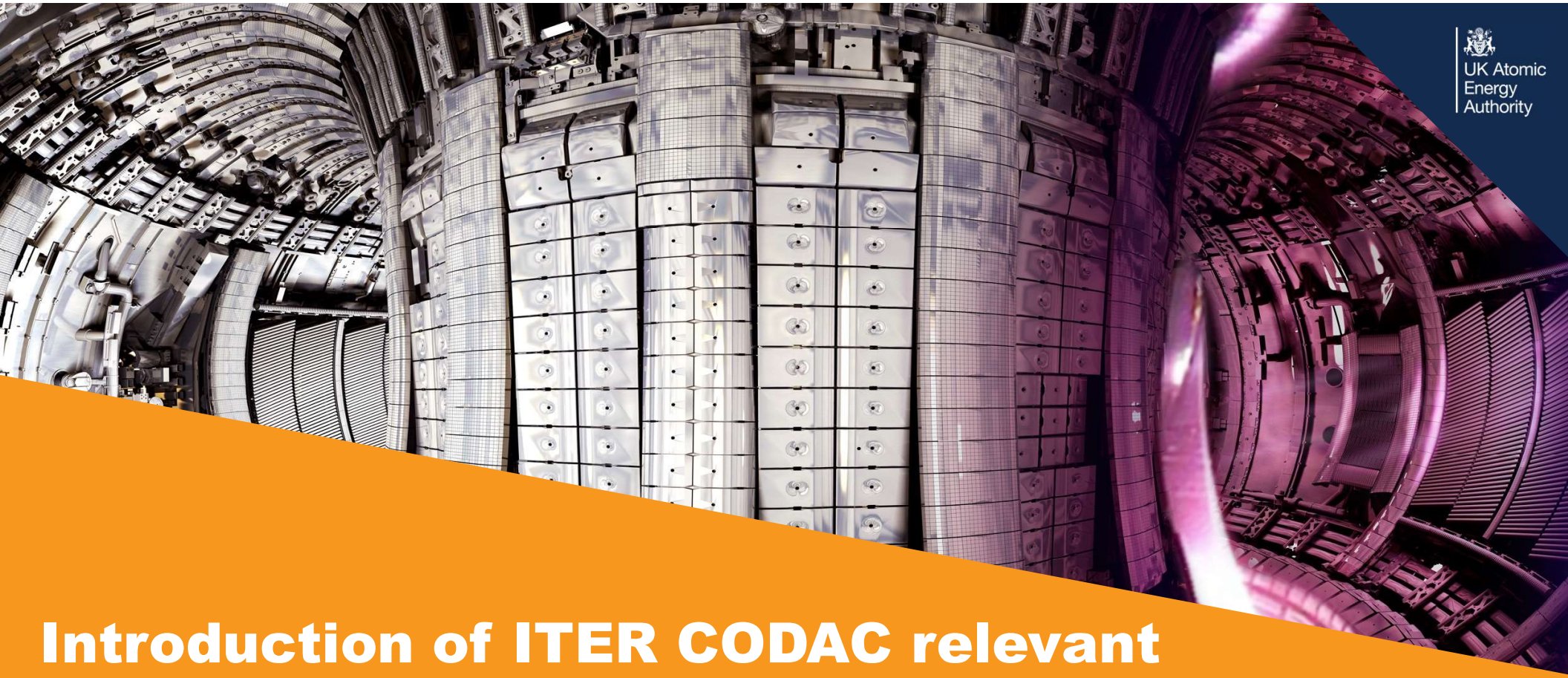

Introduction of ITER CODAC relevant Technologies on JET and MAST

John Waterhouse, UKAEA-CCFE

12th IAEA TM on Control, Data Acquisition and Remote Participation , Daejeon, 13-17 May 2019

Contract for the Operation of the JET Facilities Co-Funded by Euratom
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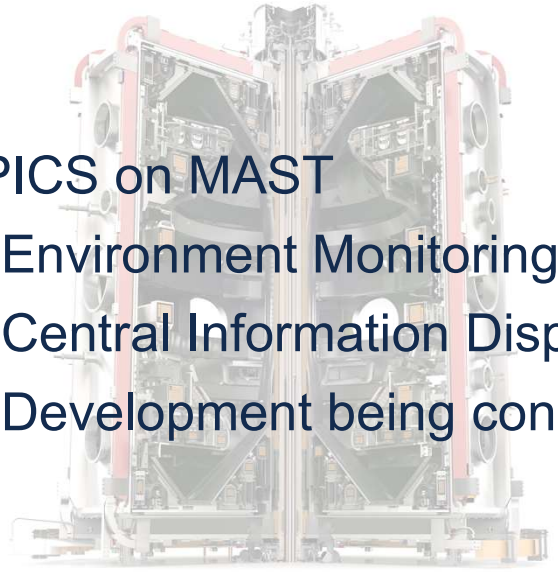

EPICS on MAST

- Environment Monitoring
- Central Information Display
- Development being considered

EPICS Training

EPICS on JET

- CODAS integration
- Filter wheel controller
- Radiation Protection Instrumentation
- Turbomolecular pump controllers
- Other possible developments

Extension of JET real-time Network

- CODAS integration and performance testing
- JET architecture for ITER CODAC SDN
- Other possible developments

Introduction

UK Atomic Energy Authority

Long history, and stable, reliable JET CODAS infrastructure

Independent development on both JET and MAST

Some significant gaps with slow controls and monitoring on MAST

Strong desire for common approach on JET and MAST

Strong desire to gain experience with ITER CODAS technologies

We can only justify new developments if we don't already have a working and maintainable solution that can be repeated (step and repeat)

However, we have been able to introduce EPICS based systems on JET and MAST

Extended JET real time networks using ITER CODAC SDN.

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EPICS Training at Culham

UK Atomic Energy Authority

Active member of the local EPICS community

- Attend and host EPICS meetings

In-house EPICS training course based on the Cosylab and Tessella material

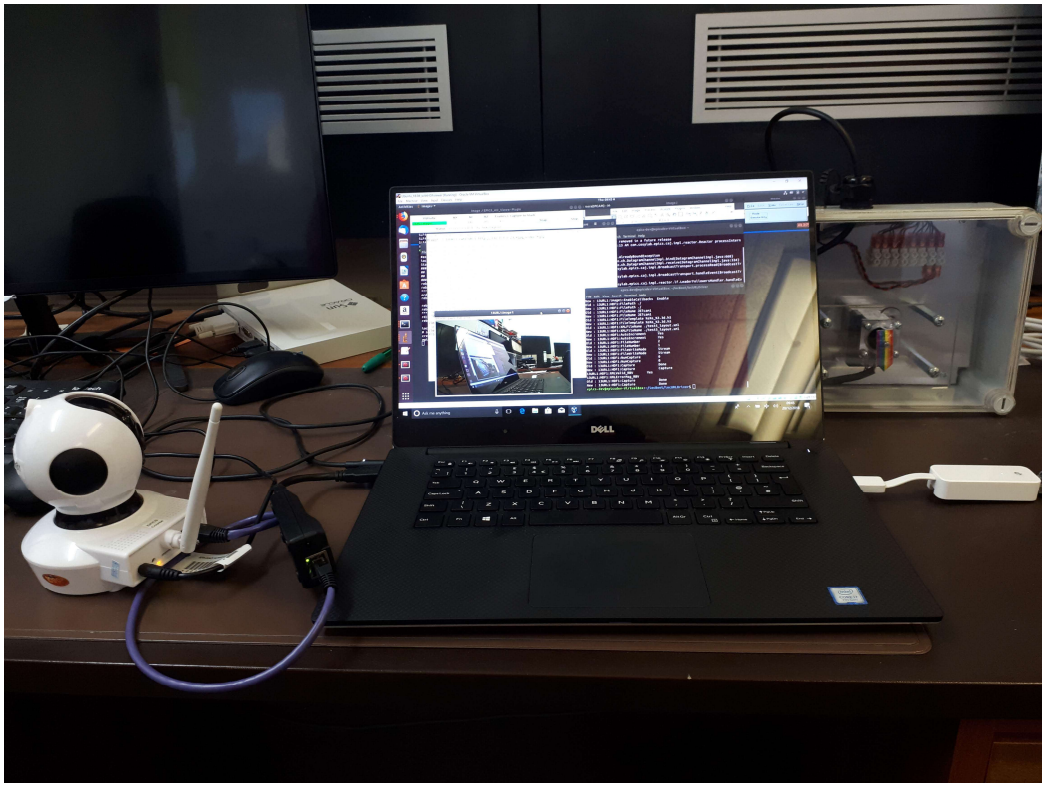
EPICS training course

Self-study modules

- EPICS and EPICS modules
- CSS

Hands on training

- LEDs driven from a RaspberryPi
- Motor controller (clock)
- Camera



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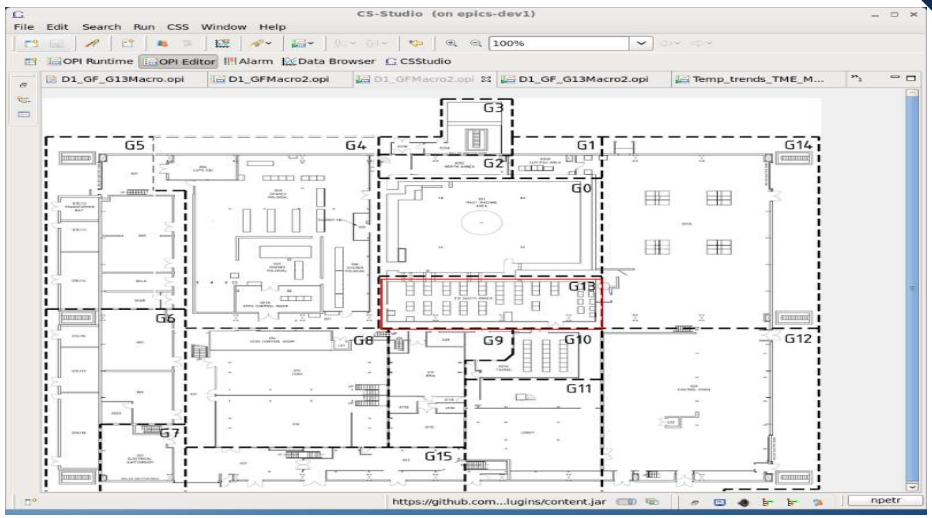
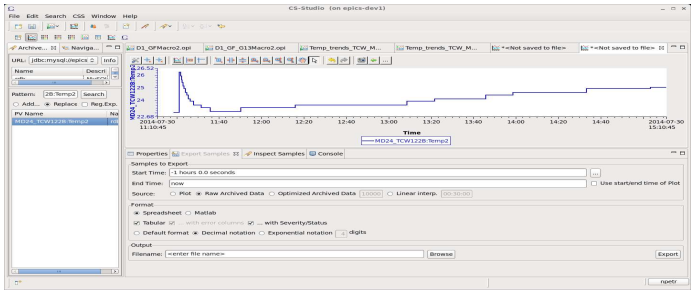
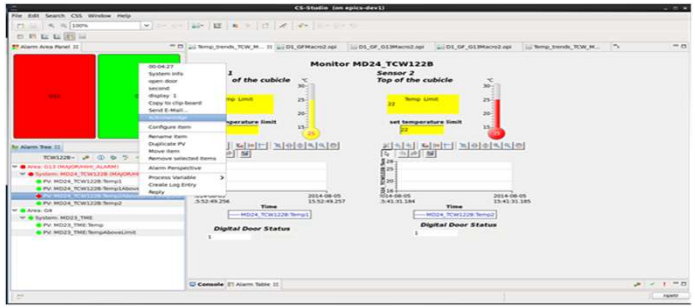
MAST Cubicle Environment Monitoring

- No standard slow monitoring and control infrastructure
  - no EPICS
- Simple proof of principle application
  - Cubicle environment monitoring
- Standard cots snmp environment monitor
  - PAPOUCH TME temperature sensor
  - TERACOM TCW 122B-CM
    - also provide contact for door monitoring
- EPICS IOC already available
- CSS HMI (BOY)
- Logging (BEAUTY)
- Alarms (BEAST)
- Python script to regenerate EPICS database and BOY when sensors are added

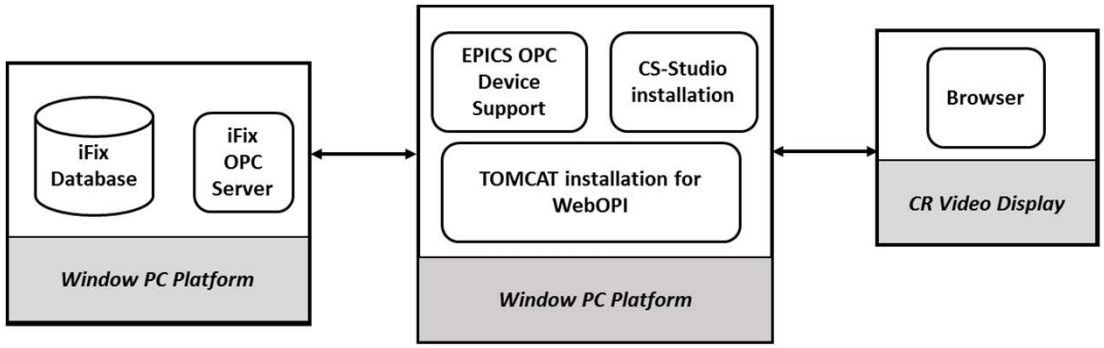


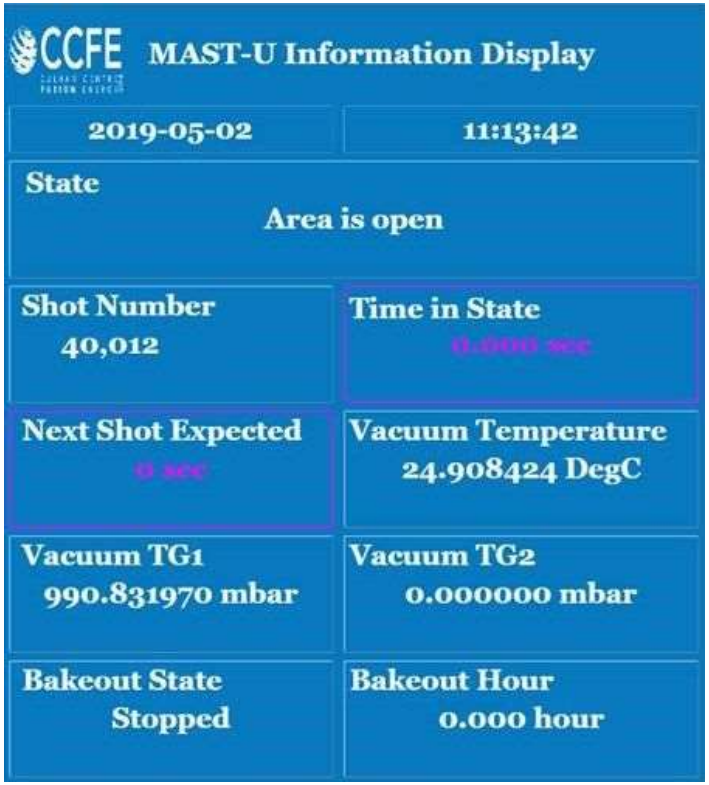




1. MAST Central Information Display

- EPICS IOC implementing iFIX OPC connection to the control system OPC server (Windows/PC)
- HMI implemented within Tomcat WebOPI (Windows/PC)
  - Web output proxied through MAST firewall giving read only access



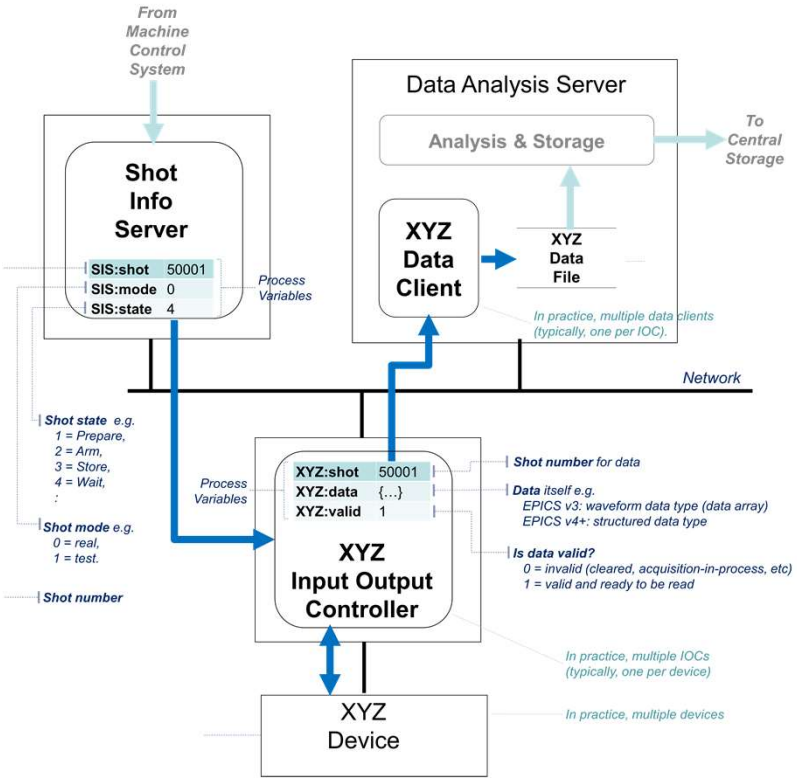


An enabling development that opens up two possibilities
- Replacement of some or all of the iFIX systems with EPICS/CSS
- EPICS managed data acquisition systems

Conceptual data acquisition design for fusion facilities at Culham using EPICS

The use of EPICS for control is well-established. Its use for data-acquisition is less well developed. However, with the introduction of modules such as Area Detector (to capture video data) and the advent of structured data-types for process variables, EPICS becomes more functional in this regard.

The fusion experiments at the CCFE have a requirement to perform shot-based data-acquisition. The figure presents one possible high-level design for how this might be achieved using EPICS.



Other MAST Developments

Data acquisition for spectroscopic CCD cameras

MAST has 8 models of camera from 4 camera manufacturers

EPICS areaDetector extension being considered

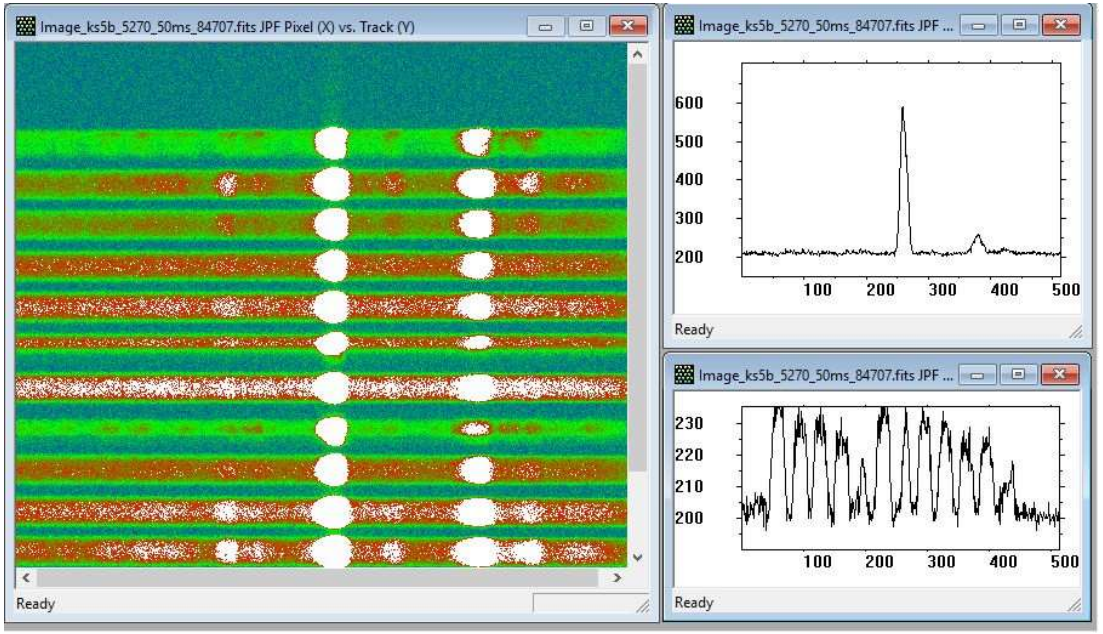


Image taken from KS5 on JET

JET EPICS Integration

JET CODAS has an extensive, integrated, well established slow control and monitoring infrastructure

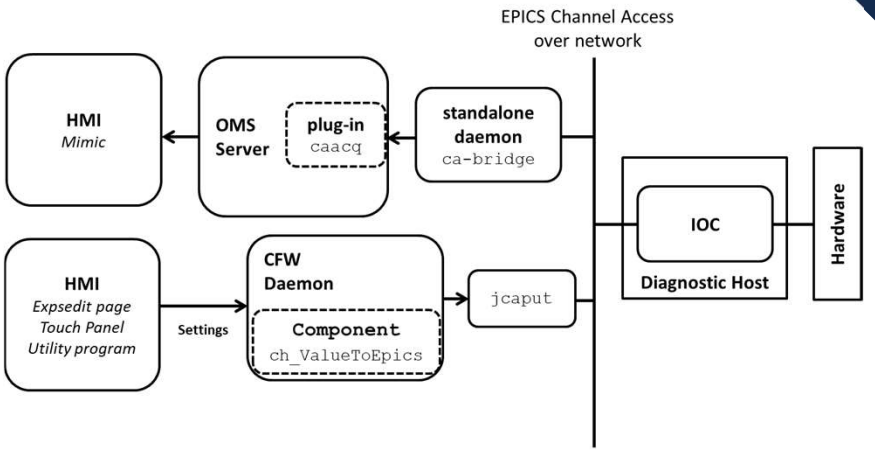
- Point (150000), alarms (12000), trends (7000), logic and sequences, mimic (3000), control panels, role based security, read only access over the online firewall

So why change?

- Developed in isolation – like many systems at the time
- Developed a very long time ago for Norsk Data systems and ported to Oracle Solaris
- Difficult to migrate to new hardware/operating systems
- Becoming increasing difficult to support

Introduce EPICS

- And build a bridge
- Access to a vast body of well supported (open source) software
- Cross platform support (Windows and Linux)
- ITER compatible
- Introduce some compatibility with MAST
- Contribute back to the community



One of my software/control engineers said *"its great, I have integrated this device into CODAS without writing a single line of code"*

JET Spectroscopy Filter Wheel Control

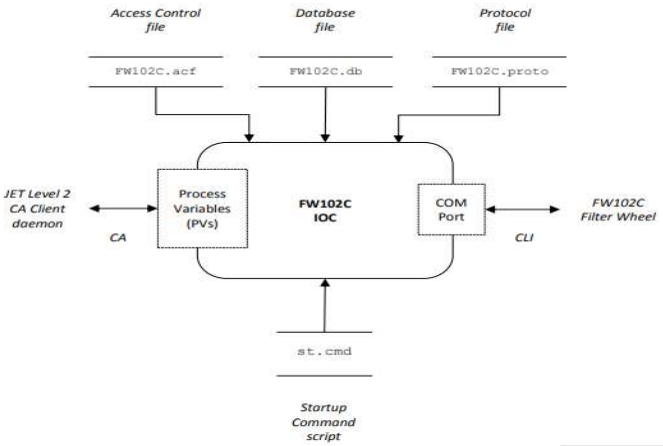
Thorlabs FW102C filter wheel
- high-precision, motor-driven, six-position filter wheel
- its text-based command line interface (CLI) protocol

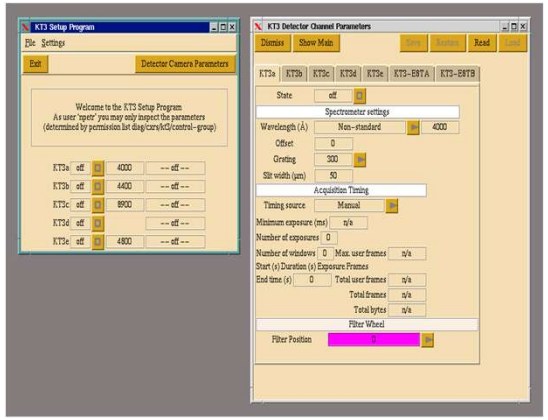
EPICS IOC streamDevice support module.

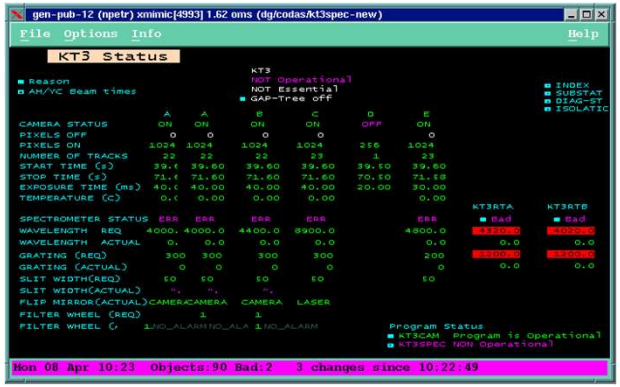
General purpose controller, suitable for managing an FW102C filter wheel in a variety of applications

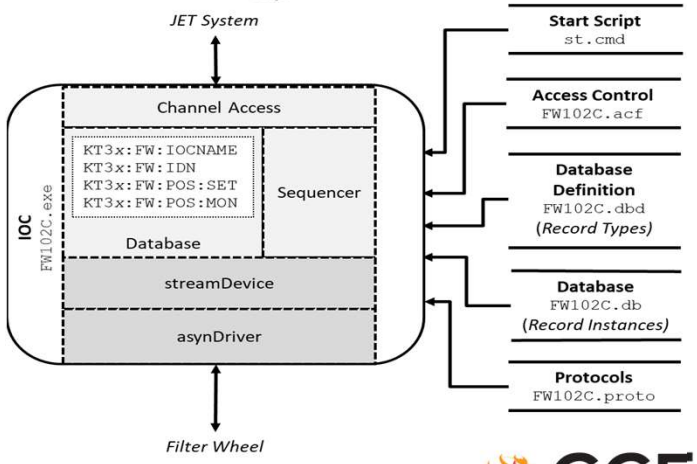
Full integration with JET CODAS

Deployed to
- JET KT3 Diverter Spectroscopy system
- JET KLDT_E5WD physics camera (currently in development)









JET Turbomolecular Pump Control

PLC control to interlock with valves and gauges etc
Specific pump controller for detail monitoring and specialist controls.

Oerlikon LeyboldTurbo specific EPICS IOC

- Engineering data
  - Pump rotation speed,
  - Converter temperature
  - Motor current
  - Pump temperature
  - Circuit voltage
  - Error status
- On/off and reset controls
- USS (Universal Serial Specification Interface Protocol) communication protocol and the EPICS application has been developed using the EPICS asynDriver module. Implemented on Windows
- Integration with JET CODAS

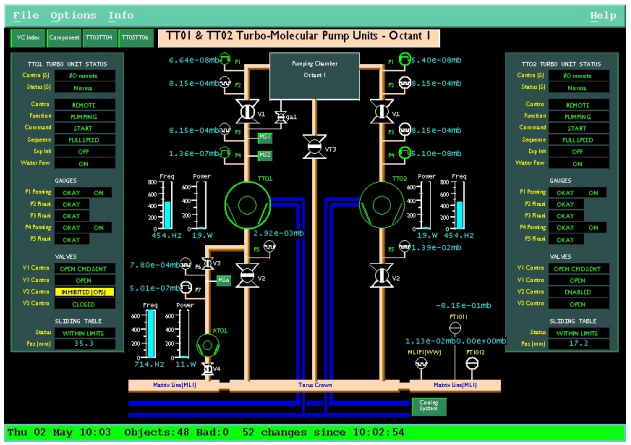
Agilent - Tritium compatible
2300 main turbomolecular pumps

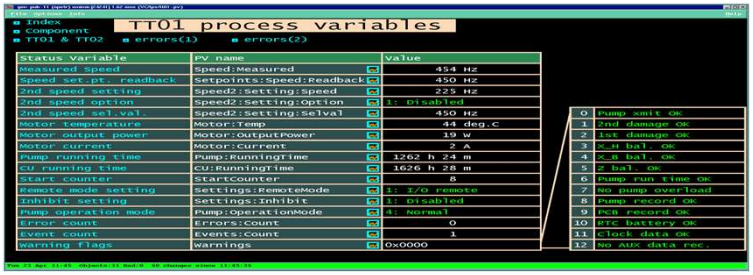
- Engineering data
- Controls (only reset made accessible to the operators)

550 diagnostic turbomolecular pumps

- Engineering data
- No controls

Serial interface using the EPICS streamDevice. AsynDriver module handles the serial port. Implemented on Windows
Integration with JET CODAS





Edwards STP-A2203 Series Turbomolecular Pump/SCU-1600 Control Unit.
EPICS IOC controls

- Engineering data
  - pump rotation speed
  - motor current
  - motor temperature
- Controls
  - Set the rotation speed
  - On/off
- Serial interface using the EPICS streamDevice. AsynDriver module handles the serial port. Developed on Linux and then built and deployed to Windows
- Integration with JET CODAS

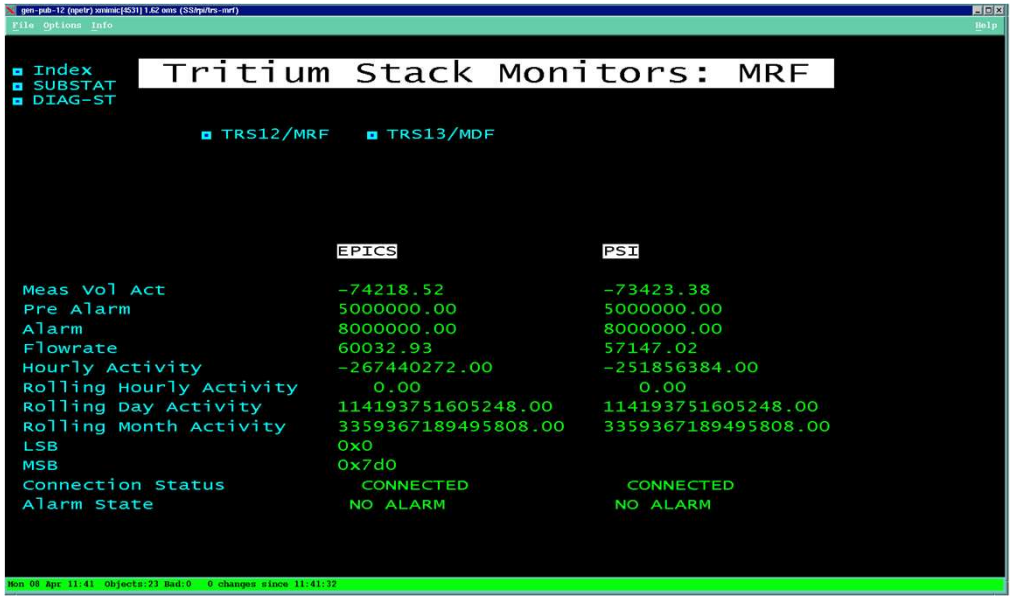
JET Radiation Protection Instrumentation

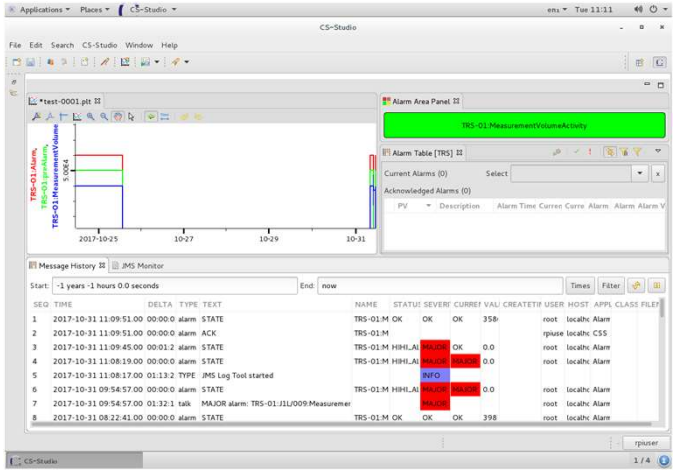
Premium Analyse Tritium Monitors

- EPICS Modbus/TCP-IP device
- Periodic polling
- Full integration with JET CODAS
- Trends recoded in JET CODAS
- Hosted on a virtual Linux server

2 currently deployed but this is due to expand to 13

Full integration with JET CODAS

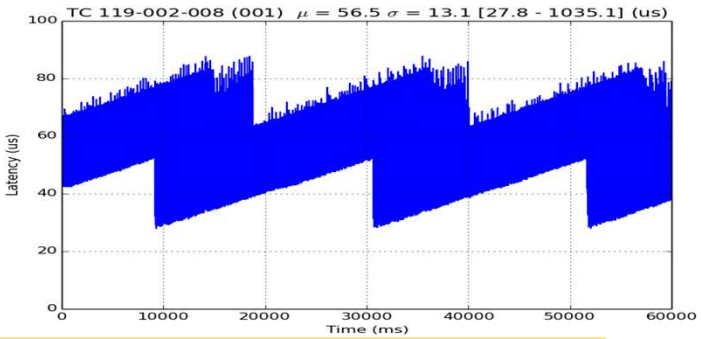




JET Real Time Network Extension using ITER CODAC SDN

- Real-time control & Real-time protection
- Current system based on ATM technology
  - VXWorks/PowerPC, Windows/PC, Linux/PC
  - ATM cards difficult to source & some only work in one direction
- Technology refresh & more computational power
- ITER CODAC Ethernet/SDN
- Intel Pro1000 nics and Gigabit edge with 10 Gigabit interconnects using Extreme switches

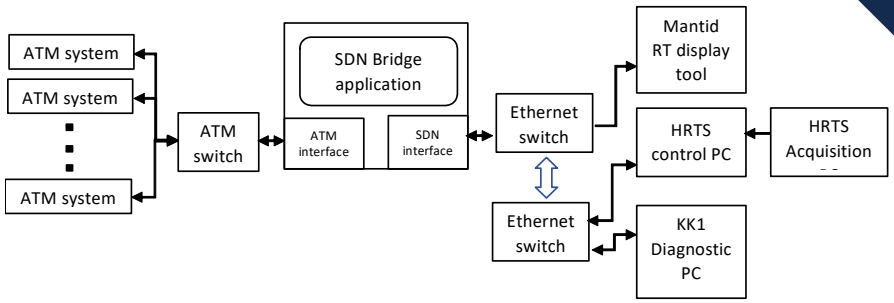
nic and switch performance tests
Using same test techniques as for an ITER/F4E real time network qualification contract – udp multicast transmitter and receiver
nic – nic
nic – switch – nic
nic – switch – switch – nic
With and without an aggressor injecting additional high network traffic

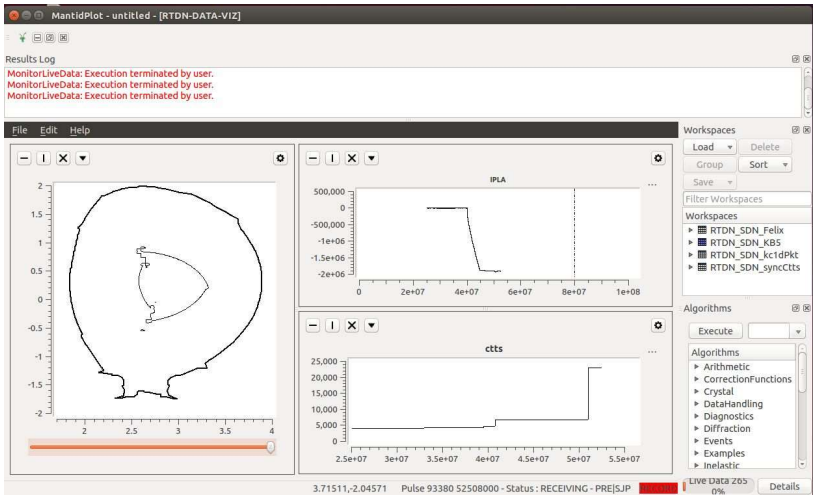


Typical performance
not seen with the ITER technology

JET architecture for ITER CODAC SDN

- JET real-time network/ATM – ITER CODAC Ethernet/SDN bridge
- MARTe application
- Initially unidirectional
  - Real-time Flux surface reconstruction and real-time display based on Mantid
- Extended to bidirectional
  - Loopback through the existing real time signal server
- Currently extending across 2 switches
  - Real time High Resolution Thomson scattering (HRTS) reconstruction (KE11), a MARTe V2 application
  - Real time ECE Michelson interferometer (KK1)
- Future plans
  - Enhanced real time controller
  - Move local actuator managers onto Ethernet/SDN
  - Release spares for real-time protection system





Future Developments and Possibilities

UK Atomic Energy Authority

- EPICS managed data acquisition
- EPICS areaDetector extension for spectroscopy cameras
- EPICS interface for Granville-Phillips Ion Trap Vacuum mass spectrometer
  - Development complete but not yet deployed
  - Of interest to ITER via the US DA
- EPICS archiver
- EPICS CSS based HMI's
- ITER CODAC DAN – load test in a large real word application
- ITER Real Time framework for JET RTCC2/PCS

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Conclusions

We have started to introduce EPICS on both JET and MAST

On MAST

- We have implemented a proof of principle application to monitor cubicles
- Implemented a Central information Display that opens up the way for EPICS managed data acquisition systems

On JET

- We have built a bidirectional bridge between JET CODAS and EPICS
- Implemented spectroscopy filter wheel controller
- Implemented several turbomolecular pump controllers
- Implemented interface to Radiation Protection Instrumentation

Thereby providing some commonality between JET and MAST by utilising technologies to be used in ITER CODAC

We are looking forward to the possibility of developing EPICS managed data acquisition systems, possibly camera based spectroscopy

On JET we have extended the ATM based real-time network using the ITER CODAC SDN technology over Ethernet.

- Development of a real time boundary reconstruction display with an SDN data feed
- Developing real-time data reconstruction for High Resolution Thomson Scattering diagnostic (KE11) and ECE Michelson Interferometer diagnostic (KK1) that stream data onto the SDN extension to the real-time network

Looking forward to developing a new SDN based real-time control system, based on ITER real time framework for JET post 2020

We would also like to be able to develop an ITER CODAC like fast controller that uses EPICS, SDN and DAN

Acknowledgement

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The JET CODAS Group
The MAST DATAC Group
CCFE, Culham Science Centre, Abingdon, Oxfordshire, OX14 3DB, UK.

EPICS training materials based on those from:
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Cosylab, d. d., Control System Laboratory, Gerbičeva ulica 64, SI-1000 Ljubljana, Slovenia.

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Introduction of ITER CODAC relevant Technologies on JET and MAST

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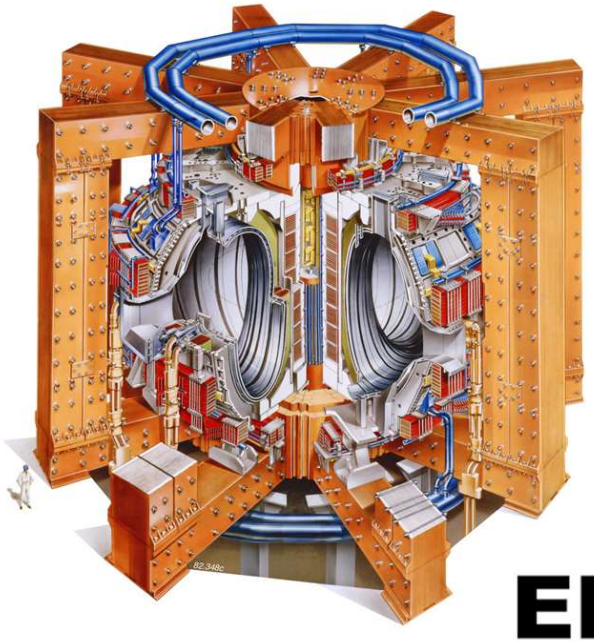

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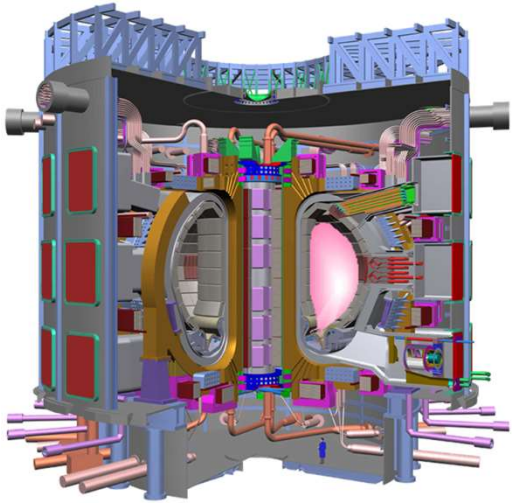

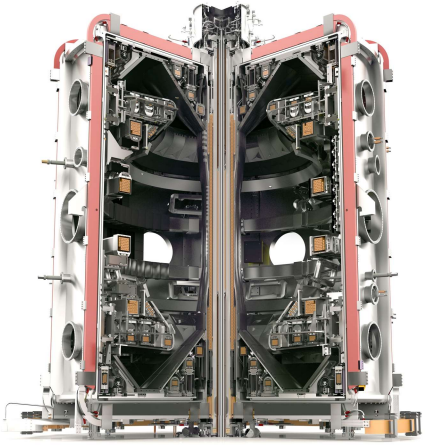

EPICS

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